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&
ABSTRACTS OF INVITED LECTURES AND PROGRESS REPORTS

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ELECTRON IMPACT STUDY OF AUTOIONIZING STATES IN NEON

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Abstract. We present an experimental study on autoionizing states in neon performed by using a crossed electron-atom beams apparatus. The ejected electron energy spectra of neon upon electron excitation are presented for the incident energy range from 40 eV to 1000 eV. The present study brings an extension to previously published results regarding several aspects. Moreover, the measured ejected electron energy spectra in neon were calibrated according to ejected electron spectra in helium, which was introduced into the chamber at the same time in a mixture with neon. We argue that the usual direct method of calibration by using dominant features in neon, could suffer from reduced precision due to an influence of resonance processes.

1. INTRODUCTION

Autoionizing states and resonances in neon were studied very extensively in the past by different experimental techniques [1,2]. However, in the case of neon, these states overlap with resonances, therefore their separation and assignment is difficult to perform with a high precision. According to our knowledge, until now there is no an electron-atom experiment in which these features are separated clearly and with high accuracy. In the present contribution, we report a detailed experimental study on autoionizing states in neon by using a high-resolution, standard crossed electron-atom beams collision experiment. We believe that the present results can contribute to better understanding of both autoionization processes in neon upon electron excitation and the intereference between auoionizing states and resonant processes.

2. EXPERIMENTAL APPARATUS AND PROCEDURE

The apparatus has been already presented at the 2nd National Conference on Electronic, Atomic, Molecular and Photonic Physics [3]. The spectrometer OHRHA consists of a high energy electron gun, a high resolution hemispherical analyzer, a hypodermic needle as a source of effusive beam of target gas and a Faraday cup as a collector for the electron beam. The electron gun was designed by Omicron Vakuumphysik Gmbh for electron impact energies from 10 eV to 2.5 keV with a resolution of 0.5 eV and an electron current in the range from 1 to 15 μA). In these measurements the position of the electron gun is fixed at 90° in reference to the gas beam.

After collisions of incident electrons with the target atoms, the ejected electrons are collected by multi–element zoom lens at the entrance of the analyzer. The hemispherical energy analyzer (EA 125 HR, Omicron) has a mean radius of 125 mm and a variable entrance/exit slits. It is equipped with 7 channeltrons for electron detection and its ultimate projected energy resolution is of the order of 10 meV, depending on the type of experiment (XPS, AUGER and EIS). The residual magnetic field was reduced by using two μ metal shields, one inside and the other outside the vacuum chamber. Moreover, both the analyzer and the lenses are shielded separately. The vacuum chamber is homemade and is pumped by three turbo molecular pumps. The background pressure was $4x10^{-7}$ mbar, while the working pressure with neon was $3x10^{-6}$ mbar. For a valuable measurement it was necessary to reach stable working conditions, pressure and electron current. Under these conditions the satisfied statistics for one measurement was reached for less than one hour.

The apparatus is not designed for experiments with low-energy electrons; however, we succeeded to perform measurements in this energy region, as well, thanks to the high efficiency of detecting system and appropriate adjustment of parameters. All collected data are stored in PC computer. The program made by OMICRON automatically controlled all parameters in hemispherical analyzer and lenses, which were adjusted before every single measurement.

The estimated energy resolution in ejected electron spectra was between 0.1 and 0.2 eV. The calibration of ejected electron energy scale was done in a mixture of neon and helium at high impact energies (500, 800 eV). The calibration point is taken from ejected electron spectra of helium at 35.55 eV which corresponds to the position of the double excited $2s2p(^1P)$ state at 60.130 eV [4]. The overall uncertainty is about 0.06 eV. It should be pointed out that an analogue, direct calibration of the neon spectra by using its strong spectral features is not precise enough due to the existence of nearby resonances. The resonant process, which is close in energy to the spectral feature used for calibration, can influence the form of the peak, thus making the position of the feature not well defined.

3. RESULTS AND DISCUSSION

Figure 1 shows ejected electron spectra taken at different electron energies. The goal of this presentation is to show main characteristics of the spectrometer, focal properties of the lenses, transmission and resolution in the large electron energy range. Moreover, the presented spectra show the changes in the form of spectral features with changing the incident electron energy (E_e).

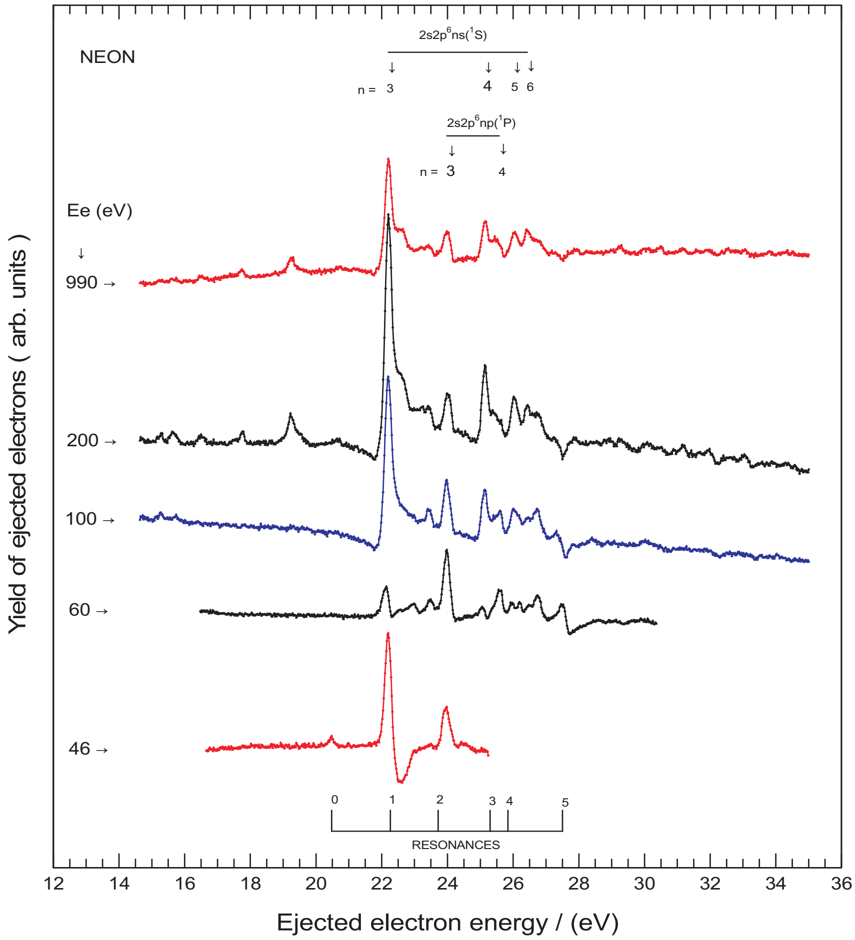

Figure 1. Autoionizing states and resonances of Neon recorded as ejected electron spectra at an ejection angle of 90°, in the energy region from 14 to 35 eV in steps of 0.020 eV, with electron incident energies (E_e) from 46 to 990 eV (shown on the left hand side of the figure).

The autoionizing states and resonances are shown in the ejected electron energy range between 14 and 35 eV (figure 1), that corresponds to the excited energies between 35.56 and 56.56 eV since the ionization potential of Ne is 21.56 eV. The dominant features in the spectra lie in the energy region between 21 and 29 eV kinetic energy (42.56 to 50.56 eV of excited energies).This energy region has been studied very extensively in the past in electron, photon and ion experiments. Two series of excited states are identified: $2s2p^6ns(^1S)$ and $2s2p^6np(^1P)$, as well as resonances. The first very intense feature $2s2p^63s(^1S)$ at high impact energies (100 to 990 eV), is a mixture between a resonance and the autoionizing state. Its intensity decreases when the electron energy approaches the threshold of the excited state. At 46 eV of incident electron energy, about 2.3 eV above the threshold for this state, the resonance is dominant and the peak was shifted to higher ejected energy. The first member of the second series $2s2p^6 3p(^1P)$ does not have strong contribution from resonances. Therefore, its intensity does not change significantly with changing the incident electron energy and it can be a referent point for calibration.

Finally, it should be noted that the resonances in neon have been also studied very extensively in the past and the present measurements show only a part of known resonant processes in this energy region (see Buckman and Clark [2] for more details).

4. CONCLUSION

In conclusion, we have presented experimentally obtained ejected electron spectra of neon, upon electron excitation in the incident energy range from 40 eV to 1000 eV. The present study on autoionizing states in neon brings an extension to previously published results with respect to several aspects: the large range of incident electron energy, the high-energy resolution and the large range of kinetic energy of ejected electrons. Moreover, a unique method has been used to perform the energy calibration of the measured spectra, based on the calibration of ejected electron spectra of helium, which was introduced into the chamber at the same time in a mixture with neon. Finally, we argue that the usual direct method of calibration, by using dominant $2s2p^6 3s(^1S)$ feature in neon, could suffer from reduced precision due to undefined both position and profile of the feature which is influenced by the nearby resonance.

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